

## Collaboration with people in University of Maryland (UMD)

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During the period October 2020 – May 2021, I joined the collaboration with the excellent people in Maryland, Srivatsa Tata, Danny Bulmash, and Maissam Barkeshli. The collaboration was about the study of the (2+1)-dimensional fermionic topological phases with global symmetries, and we were able to establish a generic and powerful framework of characterizing the symmetry-enriched fermionic topological phases via topological invariants. Moreover, we found a way to compute the quantum anomaly of the fermionic topological phases in a systematic way. This paper was recently submitted on arXiv.

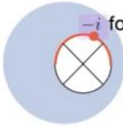
I joined this collaboration after I gave a job talk at UMD on October, and I helped them with the computation of the anomalies of fermionic topological phases. During this collaboration, it has been a great pleasure to work with and learn a lot from Danny and my future supervisor Maissam. In particular I must single out Sri for being a talented colleague and all his work in the collaboration. He had a thorough understanding on the intricate description of (3+1)-dimensional fermionic topological phases, and he never shied away from any seemingly impossible computation.

Due to their deep understanding on topological phases, I learned a lot of new things from them including about what I initially thought I had already known, which was an amazing experience for me.

### Partial time reversal as unoriented topological action

$$(|\{\xi_j\}_{j \in I}\rangle \langle \{\chi_j\}_{j \in I}|)^{T_1} = |\{-i\chi_j\}_{j \in I_1}, \{\xi_j\}_{j \in I_2}\rangle \langle \{-i\xi_j\}_{j \in I_1}, \{\chi_j\}_{j \in I_2}|$$

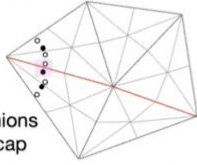
➤ factor assigns  $\pm i$  to fermions on the orientation reversing defect



$-i$  for fermions on a cross-cap

$\text{tr}_I(\rho_I \rho_I^{T_1})$

⇔



$\pm i$  for fermions on a cross-cap

Grassmann integral  $\sigma(M, \alpha)$

➤ We can make this correspondence more precise. E.g., for (1+1)d Kitaev wire,

<p> ground state&gt; on a ring = path integral on a disc</p> $Z[\eta] \propto \sum_{\{\alpha\} \in H^1(M, \mathbb{Z}_2)} \sigma(\alpha) (-1)^{\int \eta \cup \alpha}$	<p>we can explicitly prove that</p> $\text{tr}_I(\rho_I \rho_I^{T_1}) = Z[\mathbb{RP}^2, \eta] \in \mathbb{Z}_8$
<p>valid for more generic lattice pin- theory [Inamura=RK=Ryu]</p>	




Figure: Discussion during the job talk that I gave in UMD